Heating Mitigation During Charge and Discharge via Pulsed Anode-Cathode Exchange Mediated by Capacitor for Improved Charging Rates and Capacities

2 December 2023
Simon Edwards
Research Acceleration Initiative

Introduction

Wear prevention in the form of anode-collocated countervailing electron emission has as its advantage that it dramatically extends the lifespan of lithium-ion batteries (ibid. 15 September 2023) while having as its disadvantage that thermal output is increased during both charge and discharge, a fact which slightly constrains maximal charge and discharge rates and does nothing to improve the capacity of a battery or the speed with which it may safely accumulate a charge without risk of undue wear or fire.

A novel approach to mitigating heating during charge and discharge is called for which may allow existing anodes and electrolytes to safely tolerate ultra-rapid charge and the storage of greater amounts of energy.

Abstract

While it is well-known that the passage of electricity through a medium generally results in the heating of that medium, the mechanistic cause of this heating has not been sufficiently studied.

Borrowing from conclusions reached in the publication of 8 September 2023 concerning the prevention of the heating of missile integuments, it stands to reason that a similar dynamic is at play with respect to electrons flowing into an anode as are at play with respect to air molecules interacting with the skin of a missile or aircraft.

When a battery is charged or discharged, electrons flow in a non-synchronized pseudorandom manner. They tend to move like a madding crowd bursting through the doors of a department store on Black Friday rather than in neat, two-dimensional walls. As was explored on 15 September 2023, it was posited that the tendency of electrons' spin orientations (and thus magnetic influence on anode material) tends to be repetitious, with certain areas of the anode being well-trodden and other areas not being affected. This leads to the formation of nano-scale cracks in the anode which eventually develop into the inert reactant material layer associated with lithium-ion batteries at the end of their lifespan. As studies have demonstrated, it is not heating that causes this wear (although heating may be catastrophic in some cases,) but the exertion of magnetic moment by the flowing electrons. The greater the density of the electron flow i.e. the more quickly one attempts to charge such a battery, the greater the strength of these combined fields and the more stress is exerted upon specific

areas of the anode, much as a heavy anvil exerting force on a small area has a disproportionate effect on the area in question.

As was explained on 15 September 2023, this wear can be prevented via the incorporation of capacitors within the anodes themselves which regurgitate electricity in a countervailing direction which may interact with incoming electrons, randomizing their spin orientations so that anode wear is equalized. While this introduces a certain level of inefficiency, it non-trivially slows wear, extending the life of batteries.

The incorporation of capacitors on the cathode side in such a battery may be used in a very different manner to accomplish a different goal: Allowing for the speedy charge of lithium-ion batteries while mitigating heating.

The cause of heating in these batteries, much as in the case of the skin of aircraft, has to do with the tendency of individual flowing electrons to exert influence on the nuclei of atoms comprising the anode, resulting in the cumulative perturbation (and thus, heating) of the anode. It stands to reason that if walls of air hitting an aircraft skin (rather than randomly distributed air molecules of roughly equal pressure) result in less acoustic generation in the skin and therefore less heating, walls of electrons in two-dimensional formations would, through the mutual cancellation of forces coming from different directions relative to individual atoms of the anode material, tend to produce less heating during charge and discharge. Once again using the metaphor of the crowd rushing into a department store, it is the difference between a person shoving past you from your left or right exclusively and two people passing on either side at the same time. A person blowing by from just one side might knock you off your feet, but two rude shoppers blowing past in perfect unison would have a stabilizing influence which would leave one in roughly the same position as prior to their passage.

By pulsing electrons as they flow and thus ensuring that electrons move as phalanx with breaks between them rather than as continual streams, individual atoms in the anode would experience equal force from opposing sides and these forces would, to the extent that these phalanx could be maintained, would be self-negating. The wear prevention scheme mentioned on 15 September would be compatible with this new approach with the only modification being that pulsed bursts of electrons would be used in both the countervailing as well as the primary flow direction.

This design modification would naturally call for a mechanism for the conversion of these synchronized pulses of electricity back into patterns compatible with consumer electronics; a relatively straightforward proposition.

Conclusion

Depending upon experimental verification, this approach may enable somewhere between a two and four fold increase in the safe rate of charge and discharge of

lithium-ion batteries, dramatically improving their general usefulness and power-to-weight ratio in the case of automotive applications.